CIVIL AIR REGULATIONS

PART 3—AIRPLANE AIRWORTHINESS—NORMAL, UTILITY, AND ACROBATIC CATEGORIES

CIVIL AERONAUTICS BOARD
WASHINGTON, D.C.

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SUBPART A—AIRWORTHINESS REQUIREMENTS
GENERAL

§ 3.1 Scope. An airplane which has no features or characteristics rendering it unsafe for the category for which it is to be certificated is eligible for type and airworthiness certification, if it complies with all applicable provisions of this part, or, in the event it does not so comply, if it is shown to meet the same level of safety as that provided for in this part.

§ 3.2 Date of effectiveness.

(a) Airplanes certificated as a type on or after November 13, 1945, shall comply either with (1) the entire provisions of Part 4a of this chapter in effect immediately prior to November 9, 1945, or (2) the entire provisions prescribed in this part, except that airplanes certificated under (1) may incorporate provisions of (2) when the Administrator finds the standard of safety to be equivalent to the particular and all related items of the latter.

(b) Airplanes certificated as a type on or after January 1, 1947, shall comply with the provisions contained in this part. If the prototype is not flown prior to January 1, 1947, and satisfactory evidence is presented indicating that the design work of the type was well advanced prior to November 13, 1945, and the delay of completion of the airplane was due to causes beyond the manufacturer's control, the Administrator may certificate the airplane as a type under the provisions of Part 4a of this chapter which were in effect prior to November 9, 1945.

(c) Unless otherwise specified, compliance with an amendment to this part shall be mandatory only for airplanes for which application for a type certificate has been received subsequent to the effective date of such amendment.

AIRPLANE CATEGORIES

§ 3.6 Airplane categories.

(a) In this part airplanes are divided upon the basis of their intended operation into the following categories for the purpose of certification.

(1) *Normal—Suffix"N"*. Airplanes in this category are intended for nonacrobatic, nonscheduled passenger, and nonscheduled cargo operation.

(2) *Utility—Suffix "U".* Airplanes in this category are intended for normal operations and limited acrobatic maneuvers. These airplanes are not suited for use in snap or inverted maneuvers.

NOTE: The following interpretation of paragraph (a) (2) was issued May 15, 1947, 12 F.R. 3434: The phrase "limited acrobatic maneuvers" as used in § 3.6 is interpreted to include steep turns, spins, stalls (except whip stalls), lazy eights, and chandelles.

(3) *Acrobatic—Suffix "A".* Airplanes in this category will have no specific restrictions as to type of maneuver permitted unless the necessity therefor is disclosed by the required flight tests.

(4) *Deleted.*

(b) An airplane may be certificated under the requirements of a particular category, or in more than one category, provided that all of the requirements of such categories are met. Sections of this part which apply to only one or more, but not all, categories are identified in this part by the appropriate suffixes, as indicated above, added to the section number. All sections not identified by a suffix are applicable to all categories except as otherwise specified.

NOTE: For rules governing the eligibility of airplanes certificated under this part for use in air carrier operations see Parts 40, 41, 42, and 61 of this chapter.

AIRWORTHINESS CERTIFICATES

§ 3.11 Airworthiness, experimental, and production certificates. (For requirements with regard to these certificates, see Part 1 of the Civil Air Regulations.)

§ 3.12 Rescinded.

TYPE CERTIFICATES

§ 3.15 *Requirements for issuance.* A type certificate will be issued when the following requirements of §§ 3.16 to 3.19 are met.

§ 3.16 *Data required for type certification.* The applicant for a type certificate shall submit to the Administrator such descriptive data, test reports, and computations as are necessary to demonstrate that the airplane complies with the airworthiness requirements. The descriptive data shall be known as the type design and shall consist of drawings and specifications disclosing the configuration of the airplane and all design features covered in the airworthiness requirements as well as sufficient information on dimensions, materials, and processes to define the strength of the structure. The type design shall describe the airplane in sufficient detail to permit the airworthiness of subsequent airplanes of the same type to be determined by comparison with the type design.

§ 3.17 *Inspection and tests for type certification.* The authorized representatives of the Administrator shall have access to the airplane and may witness or conduct such inspections and tests as are necessary to determine compliance with the airworthiness requirements.

§ 3.18 *Inspection.* Inspections and tests shall include all those found necessary by the Administrator to insure that the airplane conforms with the following:

(a) All materials and products are in accordance with the specification given in the type design.

(b) All parts of the airplane are constructed in accordance with the drawings contained in the type design.

(c) All manufacturing processes, construction, and assembly are such that the design strength and safety contemplated by the type design will be realized in service.

§ 3.19 Flight tests.

(a) After proof of compliance with the structural requirements contained in this part, and upon completion of all necessary inspection and testing on the ground, and proof of conformity of the airplane with the type design, and upon receipt from the applicant of a report of flight tests conducted by him, there shall be conducted such official flight tests as the Administrator finds necessary to determine compliance with §§ 3.61 through 3.780.

(b) After the conclusion of the flight tests prescribed in paragraph (a) of this section such additional flight tests shall be conducted, on airplanes having a maximum certificated take-off weight of more than 6,000 pounds, as the Administrator finds necessary to ascertain whether there is reasonable assurance that the airplane, its components, and equipment are reliable and function properly. The extent of such additional flight tests shall depend upon the complexity of the airplane, the number and nature of new design features, and the record of previous tests and experience for the particular airplane model, its components, and equipment. If practicable, the flight tests performed for the purpose of ascertaining reliability and proper functioning shall be conducted on the same airplane which was used in flight tests to show compliance with §§ 3.61 through 3.780.

CHANGES

§ 3.23 *Changes.* Changes shall be substantiated to demonstrate compliance of the airplane with the appropriate airworthiness requirements in effect when the particular airplane was certificated as a type, unless the holder of the type certificate chooses to show compliance with the currently effective requirements subject to the approval of the Administrator, or unless the Administrator finds it necessary to require compliance with current airworthiness requirements.

§ 3.24 *Minor changes.* Minor changes to certificated airplanes which obviously do not impair the condition of the airplane for safe operation shall be approved by the authorized representatives of the Administrator prior to the submittal to the Administrator of any required revised drawings.

§ 3.25 *Major changes.* A major change is any change not covered by minor changes as defined in § 3.24.

§ 3.26 *Service experience changes.* When experience shows that any particular part of characteristic of an airplane is unsafe, the holder of the type certificate for such airplane shall submit for approval of the

Administrator the design changes which are necessary to correct the unsafe condition after the unsafe condition becomes known the Administrator shall withhold the issuance of airworthiness certificates for additional airplanes of the type involved until he has approved the design changes and until the additional airplanes are modified to include such changes. Upon approval by the Administrator the design changes shall be considered as a part of the type design, and descriptive data covering these changes shall be made available by the holder of the type certificate to all owners of airplanes previously certificated under such type certificate.

§ 3.27 *Application to earlier airworthiness requirements.* In the case of airplanes approved as a type under the terms of earlier airworthiness requirements, the Administrator may require that an airplane submitted for an original airworthiness certificate comply with such portions of the currently effective airworthiness requirements as may be necessary for safety.

APPROVAL OF MATERIALS, PARTS, PROCESSES, AND APPLIANCES

§ 3.31 Specifications.

(a) Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of this subchapter. The Administrator may adopt and publish such specifications as he finds necessary to administer this section, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.

(b) Any material, part, process, or appliance shall be deemed to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator, and the manufacturer so certifies in a manner prescribed by the Administrator.

DEFINITIONS

§ 3.41 *Standard atmosphere.* The standard atmosphere shall be based upon the following assumptions:

(a) The air is a dry perfect gas.

(b) The temperature at sea level is 59° F.

(c) The pressure at sea level is 29.92 inches Hg.

(d) The temperature gradient from sea level to the altitude at which the temperature becomes -67° F. is -0.003566° F. per foot and zero there above.

(e) The density ρ_0 at sea level under the above conditions is 0.002378 lbs. sec.2/ft4.

§ 3.42 *Hot-day condition.* See § 3.583.

§ 3.43 *Airplane configuration.* This term refers to the position of the various elements affecting the aerodynamic characteristics of the airplane, such as landing gear and flaps.

§ 3.44 Weights.

	Reference sections
Empty weight: The actual weight used as a basis for determining operating weights	3.73
Maximum weight: The maximum weight at which the airplane may operate in accordance with the airworthiness requirements	3.74
Minimum weight: The minimum weight at which compliance with the airworthiness requirements is demonstrated.	3.75
Maximum design weight: The maximum weight used for the structural design of the airplane.	3.181
Minimum design weight: The minimum weight condition investigated in the structural flight load conditions, not greater than the minimum weight specified in §3.75.	3.181
Design landing weight: The weight used in the structural investigation of the airplane for normal landing conditions. Under the provisions of §3.242, this weight may be equal to or less than the maximum design weight.	3.242

Unit weights for design purposes:
Gasoline....................... 6 pounds per United States gallon.
Lubricating oil............. 7.5 pounds per United States gallon.
Crew and passengers.... 170 pounds per person.

§ 3.45 Power.
One horsepower: 33,000 foot-pounds per minute.

Take-off power: the take-off rating of the engine established in accordance with Part 13, Aircraft Engine Airworthiness.

Maximum continuous power: The maximum continuous rating of the engine established in accordance with Part 13, Aircraft Engine Airworthiness.

§ 3.46 Speeds.

V_t True air speed of the airplane relative to the undisturbed air.

In the following symbols having subscripts, V denotes:

(a) "Equivalent" air speed for structural design purposes equal to $V\sqrt{\rho/\rho_0}$

(b) "True indicated" or "calibrated" air speed for performance and operating purposes equal to indicator reading corrected for position and instrument errors.

	Reference sections
Vs0 stalling speed, in the land configuration.	3.82
Vs1 stalling speed in the configurations specified for particular conditions.	3.82
Vsf computed stalling speed at design landing weight with flaps fully defected.	3.190
Vx speed for best angle of climb.	3.111
Vy speed for best rate of climb.	
Vmc minimum control speed.	
Vf design speed for flight load conditions with flaps in landing position.	3.190
Vfe flaps-extended speed.	3.742
Vp design maneuvering speed.	3.184
Vc design cruising speed.	3.184
Vd design dive speed	3.184
Vne never-exceed speed.	3.739
Vno maximum structural cruising speed.	3.740

Vh maximum speed in level flight at maximum continuous power.

§ 3.47 *Structural terms.*

Structure: Those portions of the airplane the failure of which would seriously endanger the safety of the airplane.

Design wing area, S: The area enclosed by the wing outline (including ailerons, and flaps in the retracted position, but ignoring fillets and fairings) on a surface containing the wing chords. The outline is assumed to extend through the nacelles and fuselage to the centerline of symmetry.

Aerodynamic coefficients: CL, CN, CM, etc., used in this part, are nondimensional coefficients for the forces and moments acting on an airfoil, and correspond to those adopted by the United States National Advisory Committee for Aeronautics.

CL = airfoil lift coefficient.
CN = airfoil normal force coefficient (normal to wing chord line).
CNA = airplane normal force coefficient (based on lift of complete airplane and design wing area).
CM = pitching moment coefficient.

Loads	Reference Sections
Limit load: The maximum load anticipated in service.	8.171
Ultimate load: The maximum load which a part of structure must be capable of supporting.	8.173
Factor of safety: The factor by which the limit load must be multiplied to establish the ultimate load.	8.172

Load factor or acceleration factor, n: The ratio of the force acting on a mass to the weight of the mass. When the force in question represents the net external load acting on the airplane in a given direction, n represents the acceleration in that direction in terms of the gravitational constant.

Limit load factor: The load factor corresponding to limit load.

Ultimate load factor: The load factor corresponding to ultimate load.

§ 3.48 *Susceptibility of materials to fire.* Where necessary for the purpose of determining compliance with any of the definitions in this section, the Administrator shall prescribe the heat conditions and testing procedures which any specific material or individual part must meet.

(a) *Fireproof.* "Fireproof" material means a material which will withstand heat equally well or better than steel in dimensions appropriate for the purpose for which it is to be used. When applied to material and parts used to confine fires in designated fire zones "fireproof" means that the material or part will perform this function under the most severe conditions of fire and duration likely to occur in such zones.

(b) *Fire-resistant.* When applied to sheet or structural members, "fire-resistant" material shall mean a material which will withstand heat equally well or better than aluminum alloy in dimensions appropriate for the purpose for which it is to be used. When applied to fluid-carrying lines, this term refers to a line and fitting assembly which will perform its intended protective functions under the heat and other conditions likely to occur at the particular location.

(c) Flames-resistant. "Flame-resistant" material means material which will not support combustion to the point of propagating, beyond safe limits, a flame after removal of the ignition source.

(d) Flash-resistant. "Flash-resistant" material means material which will not burn violently when ignited.

(e) Inflammable. "Inflammable" fluids or gases means those which will ignite readily or explode.

SUBPART B—FLIGHT REQUIREMENTS
GENERAL

§ 3.61 *Policy re proof of compliance.* Compliance with the requirements specified in this subpart governing functional characteristics shall be demonstrated by suitable flight or other tests conducted upon an airplane of the type, or by calculations based upon the test data referred to above, provided that the results so obtained are substantially equal in accuracy to the results of direct testing. Compliance with each requirement must be provided at the critical combination of airplane weight and center of gravity position within the range of either for which certification is desired. Such compliance must be demonstrated by systematic investigation of all probable weight and center of gravity combinations or must be reasonably inferable from such as are investigated.

§ 3.62 *Flight test pilot.* The applicant shall provide a person holding an appropriate pilot certificate to make the flight tests, but a designated representative of the Administrator may pilot the airplane insofar as that may be necessary for the determination of compliance with the airworthiness requirements.

§ 3.63 *Noncompliance with test requirements.* Official type tests will be discontinued until corrective measures have been taken by the applicant when either:

(a) The applicant's test pilot is unable or unwilling to conduct any of the required flight tests; or

(b) Items of noncompliance with requirements are found which may render additional test data meaningless or are of such nature as to make further testing unduly hazardous.

§ 3.64 *Emergency egress.* Adequate provisions shall be made for emergency egress and use of parachutes by members of the crew during the flight tests.

§ 3.65 *Report.* The applicant shall submit to the representative of the Administrator a report covering all computations and tests required in connection with calibration of instruments used for test purposes and correction of test results to standard atmospheric conditions. The representative of the Administrator will conduct any flight tests which he finds to be necessary in order to check the calibration and correction report.

WEIGHT RANGE AND CENTER OF GRAVITY

§ 3.71 Weight and balance.

(a) There shall be established, as a part of the type inspection, ranges of weight and center of gravity within which the airplane may be safely operated.

(b) When low fuel adversely affects balance or stability, the airplane shall be so tested as to simulate the condition existing when the amount of usable fuel on board does not exceed 1 gallon for every 12 maximum continuous horsepower of the engine or engines installed.

§ 3.72 *Use of ballast.* Removable ballast may be used to enable airplanes to comply with the flight requirements in accordance with the following provisions:

(a) The place or places for carrying ballast shall be properly designed, installed, and plainly marked as specified in § 3.766.

(b) The Airplane Flight Manual shall include instructions regarding the proper disposition of the removable ballast under all loading conditions for which such ballast is necessary, as specified in § 3.755-3.770.

§ 3.73 *Empty weight.* The empty weight and corresponding center of gravity location shall include all fixed ballast, the unusable fuel supply (see § 3.437), undrainable oil, full engine coolant, and hydraulic fluid. The weight and location of items of equipment installed when the airplane is weighed shall be noted in the Airplane Flight Manual.

§ 3.74 *Maximum weight.* The maximum weight shall not exceed any of the following:

(a) The weight selected by the applicant.

(b) The design weight for which the structure has been proven.

(c) The maximum weight at which compliance with all of the requirements specified is demonstrated, and shall not be less than the sum of the weights of the following:

(1) The empty weight as defined by § 3.73.

(2) One gallon of usable fuel (see § 3.437) for every seven maximum continuous horsepower for which the airplane is certificated.

(3) The full oil capacity.

(4) 170 pounds in all seats (normal category) or 190 pounds in all seats (utility and acrobatic category) unless placarded otherwise.

§ 3.75 Minimum weight. The minimum weight shall not exceed the sum of the weights of the following:

(a) The empty weight is defined by § 3.73.

(b) The minimum crew necessary to operate the airplane (170 pounds for each crew member).

(c) One gallon of usable fuel (see § 3.437) for every 12 maximum continuous horsepower for which the airplane is certificated.

(d) Either 1 gallon of oil for each 25 gallons of fuel specified in (c) or 1 gallon of oil for each 75 maximum continuous horsepower for which the airplane is certificated, whichever is greater.

§ 3.76 *Center of gravity position.* If the center of gravity position under any possible loading condition between the maximum weight as specified in § 3.74 and the minimum weight as specified in § 3.75 lies beyond (a) the extremes selected by the applicant, or (b) the extremes for which the structure has been proven, or (c) the extremes for which compliance with all functional requirements were demonstrated, loading instructions shall be provided in the Airplane Flight Manual as specified in § 3.777-3.780.

PERFORMANCE REQUIREMENTS
GENERAL

§ 3.80 Alternate performance requirements . The provisions of §§ 3.84, 3.85, 3.86, and 3.112 (a)(2)(ii) shall not be applicable to airplanes having a maximum certificated take-off weight of 6,000 lbs. or less. In lieu thereof, such airplanes shall comply with the provisions of §§ 3.84a, 3.85a, 3.87, and 3.112(c).

§ 3.81 *Performance.* The following items of performance shall be determined and the airplane shall comply with the corresponding requirements in standard atmosphere and still air.

§ 3.82 *Definition of stalling speeds.*

(a) Vso denotes the true indicated stalling speed, if obtainable, or the minimum steady flight speed at which the airplane is controllable, in miles per hour, with:

(1) Engines idling, throttles closed (or not more than sufficient power for zero thrust),

(2) Propellers in position normally used for take-off,

(3) Landing gear extended,

(4) Wing flaps in the landing position,

(5) Cowl flaps closed,

(6) Center of gravity in the most unfavorable position within the allowable landing range,

(7) The weight of the airplane equal to the weight in connection with which Vso is being used as a factor to determine a required performance.

(b) Vs1 denotes the true indicated stalling speed, if obtainable, otherwise the calculated value in miles per hour, with:

(1) Engines idling, throttles closed (or not more than sufficient power for zero thrust),

(2) Propellers in position normally used for take-off, the airplane in all other respects (flaps, landing gear, etc.) in the particular condition existing in the particular test in connection with which Vs1 is being used,

(3) The weight of the airplane equal to the weight in connection with which Vs1 is being used as a factor to determine a required performance.

(c) These speeds shall be determined by flight tests using the procedure outlined in §3.120.

§ 3.83 *Stalling speed.* Vso at maximum weight shall not exceed 70 miles per hour for (1) single-engine airplanes and (2) multiengine airplanes which do not have the rate of climb with critical engine inoperative specified in §3.85 (b).

TAKE-OFF

§ 3.84 Take-off.

(a) The distance required to take off and climb over a 50-foot obstacle shall be determined under the following conditions:

(1) Most unfavorable combination of weight and center of gravity location,

(2) Engines operating within the approved limitations,

(3) Cowl flaps in the position normally used for take-off.

(b) Upon obtaining a height of 50 feet above the level take-off surface, the airplane shall have attained a speed of not less than 1.3 Vs1 unless a lower speed of not less than Vx plus 5 can be shown to be safe under all conditions, including turbulence and complete engine failure.

(c) The distance so obtained, the type of surface from which made, and the pertinent information with respect to the cowl flap position, the use of flight-path control devices and landing gear retraction system shall be entered in the Airplane Flight Manual. The take-off shall be made in such a manner that its reproduction shall not require an exceptional degree of skill on the part of the pilot or exceptionally favorable conditions.

§ 3.84a *Take-off requirements - airplanes of 6,000 lbs. or less.* Airplanes having a maximum certificated take-off weight of 6,000 lbs. or less shall comply with the provisions of this section.

(a) The elevator control for tail wheel type airplanes shall be sufficient to maintain at a speed equal to 0.8 Vs1 an airplane attitude which will permit holding the airplane on the runway until a safe take-off speed is attained.

(b) The elevator control for nose wheel type airplanes shall be sufficient to raise the nose wheel clear of the takeoff surface at a speed equal to 0.85 Vs1.

(c) The characteristics prescribed in paragraphs (a) and (b) of this section shall be demonstrated with:

(1) Take-off power,

(2) Most unfavorable weight,

(3) Most unfavorable c.g. position.

(d) It shall be demonstrated that the airplane will take off safely without requiring an exceptional degree of piloting skill.

CLIMB

§ 3.85 *Climb*—

(a) Normal climb condition. The steady rate of climb at sea level shall be at least 300 feet per minute, and the steady angle of climb at least 1:12 for landplanes or 1:15 for seaplanes with:

(1) Not more than maximum continuous power on all engines,

(2) Landing gear fully retracted,

(3) Wing flaps in take-off position,

(4) Cowl flaps in the position used in cooling tests specified in §§ 3.581-3.596.

(b) Climb with inoperative engine. All multiengine airplanes having a stalling speed Vso greater than 70 miles per hour or a maximum weight greater than 6,000 pounds shall have a steady rate of climb of at least 0.02 Vso in feet per minute at an altitude of 5,000 feet with the critical engine inoperative and:

(1) The remaining engines operating at not more than maximum continuous power,

(2) The inoperative propeller in the minimum drag position,

(3) Landing gear retracted,

(4) Wing flaps in the most favorable position,

(5) Cowl flaps in the position used in cooling tests specified in §§ 3.581-3.596.

(c) Balked landing conditions. The steady angle of climb at sea level shall be at least 1:30 with:

(1) Take-off power on all engines,

(2) Landing gear extended,

(3) Wing flaps in landing position. If rapid retraction is possible with safety without loss of altitude and without requiring sudden changes of angle of attack or exceptional skill on the part of the pilot, wing flaps may be retracted.

§ 3.85a *Climb requirements* - airplane of 6,000 lbs. or less . Airplanes having a maximum certificated take-off weight of 6,000 lbs. or less shall comply with the requirements of this section.

(a) Climb - take-off climb condition. The steady rate of climb as sea level shall not be less than 10 Vs1 or 300 feet per minute, whichever is the greater, with:

(1) Take-off power,

(2) Landing gear extended,

(3) Wing flaps in take-off position,

(4) Cowl flaps in the position used in cooling tests specified in §§ 3.581 through 3.596.

(b) Climb with inoperative engine. All multiengine airplanes having a stalling speed Vso greater than 70 miles per hour shall have a steady rate of climb of at least 0.02 Vso in feet per minute at an altitude of 5,000 feet with the critical engine inoperative and:

(1) The remaining engines operating at not more than maximum continuous power,

(2) The inoperative propeller in the minimum drag position,

(3) Landing gear retracted,

(4) Wing flaps in the most favorable position,

(5) Cowl flaps in the position used in cooling tests specified in §§ 3.581 through 3.596.

(c) Climb - balked landing conditions. The steady rate of climb at sea level shall not be less than 5 Vso or 200 feet per minute, whichever is the greater, with:

(1) Take-off power,

(2) Landing gear extended,

(3) Wing flaps in the landing position. If rapid retraction is possible with safety, without loss of altitude and without requiring sudden changes of angle of attack or exceptional skill on the part of the pilot, wing flaps may be retracted.

LANDING

§ 3.86 *Landing*

(a) The horizontal distance required to land and to come to a complete stop (to a speed of approximately 3 miles per hour for seaplanes or float planes) from a point at a height of 50 feet above the landing surface shall be determined as follows:

(1) Immediately prior to reaching the 50-foot altitude, a steady gliding approach shall have been maintained, with a true indicated air speed of at least 1.3 Vso.

(2) The landing shall be made in such a manner that there is no excessive vertical acceleration, no tendency to bounce, nose over, ground loop, porpoise, or water loop, and in such a manner that its reproduction shall not require any exceptional degree of skill on the part of the pilot or exceptionally favorable conditions.

(b) The distance so obtained, the type of landing surface on which made and the pertinent information with respect of cowl flap position, and the use of flight path control devices shall be entered in the Airplane Flight Manual.

§ 3.87 *Landing requirements - airplanes of 6,000 lbs. or less.* For an airplane having a maximum certificated take-off weight of 6,000 lbs. or less it shall be demonstrated that the airplane can be safely landed and brought to a stop without requiring an exceptional degree of piloting skill, and without excessive vertical acceleration, tendency to bounce, nose over, ground loop, porpoise, or water loop.

FLIGHT CHARACTERISTICS

§ 3.105 Requirements. The airplane shall meet the requirements set forth in §§ 3.106 to 3.124 at all normally expected operating altitudes under all critical loading conditions within the range of center of gravity and, except as otherwise specified, at the maximum weight for which certification is sought.

CONTROLLABILITY

§ 3.106 *General*. The airplane shall be satisfactorily controllable and maneuverable during take-off, climb, level flight, drive, and landing with or without power. It shall be possible to make a smooth transition from one flight condition to another, including turns and slips, without requiring an exceptional degree of skill, alertness, or strength on the part of the pilot, and without danger of exceeding the limit load factor under all conditions of operation probable for the type, including for multiengine airplanes those conditions normally encountered in the event of sudden failure of any engine. Compliance with "strength of pilots" limits need not be demonstrated by quantitative tests unless the Administrator finds the condition to be marginal. In the latter case they shall not exceed maximum values found by the Administrator to be appropriate for the type but in no case shall they exceed the following limits:

	Pitch	Roll	Yaw
(a) For temporary application:			
Stick	60	30	150
Wheel [1]	75	60	150
(b) For prolonged application.	10	5	20

[1] Applied to rim.

§ 3.107-U *Approved acrobatic maneuvers.* It shall be demonstrated that the approved acrobatic maneuvers can be performed safely. Safe entry speeds shall be determined for these maneuvers.

§ 3.108-A *Acrobatic maneuvers.* It shall be demonstrated that acrobatic maneuvers can be performed readily and safely. Safe entry speeds shall be determined for these maneuvers.

§ 3.109 *Longitudinal control.* The airplane shall be demonstrated to comply with the following requirements:

(a) It shall be possible at all speeds below Vx to pitch the nose downward so that the rate of increase in air speed is satisfactory for prompt acceleration of Vx with:

(1) Maximum continuous power on all engines, the airplane trimmed at Vx.

(2) Power off, the airplane trimmed at 1.4 Vs1.

(3) (i) Wing flaps and landing gear extended and

(ii) Wing flaps and landing gear retracted.

(b) During each of the controllability demonstrations outlined below it shall not require a change in the trim control or the exertion of more control force than can be readily applied with one hand for a short period. Each maneuver shall be performed with the landing gear extended.

(1) With power off, flaps retracted, and the airplane trimmed at 1.4 Vs1, the flaps shall be extended as rapidly as possible while maintaining the air speed at approximately 40 percent above the instantaneous value of the stalling speed.

(2) Same as subparagraph (1) of this paragraph, except the flaps shall be initially extended and the airplane trimmed at 1.4 Vs1, then the flaps shall be retracted as rapidly as possible.

(3) Same as subparagraph (2) of this paragraph, except maximum continuous power shall be used.

(4) With power off, the flaps retracted, and the airplane trimmed at 1.4 Vs1, take-off power shall be applied quickly while the same air speed is maintained.

(5) Same as subparagraph (4) of this paragraph, except with the flaps extended.

(6) With power off, flaps extended, and the airplane trimmed at 1.4 Vs1, air speeds within the range of 1.1 Vs1 to 1.7 Vs1 or Vf whichever is the lesser, shall be obtained and maintained.

(c) It shall be possible without the use of exceptional piloting skill to maintain essentially level flight when flap retraction from any position is initiated during steady horizontal flight at 1.1 Vs1 with simultaneous application of not more than maximum continuous power.

§ 3.110 Lateral and directional control.

(a) It shall be possible with multiengine airplanes to execute 15-degree banked turns both with and against the inoperative engine from steady climb at 1.4 Vs1 or Vy for the condition with:

(1) Maximum continuous power on the operating engines,

(2) Rearmost center of gravity,

(3) (i) Landing gear retracted and (ii) Landing gear extended.

(4) Wing flaps in most favorable climb position,

(5) Maximum weight,

(6) The inoperative propeller in its minimum drag condition.

(b) It shall be possible with multiengine airplanes, while holding the wings level laterally within 5 degrees, to execute sudden changes in heading in both directions without dangerous characteristics being encountered. This shall be demonstrated at 1.4 Vs1 or Vy up to heading changes of 15 degrees, except that the heading change at which the rudder force corresponds to that specified in § 3.106 need not be exceeded, with:

(1) The critical engine inoperative,

(2) Maximum continuous power on the operating engine(s),

(3) (i) Landing gear retracted and (ii) Landing gear extended,

(4) Wing flaps in the most favorable climb position,

(5) The inoperative propeller in its minimum drag condition,

(6) The airplane center of gravity at its rearmost position.

§ 3.111 Minimum control speed (Vmc).

(a) A minimum speed shall be determined under the conditions specified below, such that when any one engine is suddenly made inoperative at that speed, it shall be possible to recover control of the airplane, with the one engine still inoperative, and to maintain it in straight flight at that speed, either with zero yaw or, at the option of the applicant, with a bank not in excess of 5 degrees. Such speed shall not exceed 1.3 Vs1, with:

(1) Take-off or maximum available power on all engines,

(2) Rearmost center of gravity,

(3) Flaps in take-off position,

(4) Landing gear retracted.

(b) In demonstrating this minimum speed, the rudder force required to maintain it shall not exceed forces specified in § 3.106, nor shall it be necessary to throttle the remaining engines. During recovery the airplane shall not assume any dangerous attitude, nor shall it require exceptional skill, strength, or alertness on the part of the pilot to prevent a change of heading in excess of 20 degrees before recovery is complete.

TRIM

§ 3.112 Requirements.

(a) The means used for trimming the airplane shall be such that, after being trimmed and without further pressure upon or movement of either the primary control or its corresponding trim control by the pilot or the automatic pilot, the airplane will maintain:

(1) Lateral and directional trim in level flight at a speed of 0.9 Vh or at Vc, if lower, with the landing gear and wing flaps retracted:

(2) Longitudinal trim under the following conditions:

(i) During a climb with maximum continuous power at a speed between Vx and 1.4 Vs1,

(a) With landing gear retracted and wing flaps retracted,

(b) With landing gear retracted and wing flaps in the take-off position.

(ii) During a glide with power off at a speed not in excess of 1.4 Vs1,

(a) With landing gear extended and wing flaps retracted,

(b) With landing gear extended and wing flaps extended under the forward center of gravity position approved with the maximum authorized weight.

(c) With landing gear extended and wing flaps extended under the most forward center of gravity position approved, regardless of weight.

(iii) During level flight at any speed from 0.9 Vh to Vx or 1.4 Vs1 with landing gear and wing flaps retracted.

(b) In addition to the above, multiengine airplanes shall maintain longitudinal and directional trim at a speed between Vy and 1.4 Vs1 during climbing flight with the critical of two or more engines inoperative, with:

(1) The other engine(s) operating at maximum continuous power.

(2) The landing gear retracted,

(3) Wing flaps retracted,

(4) Bank not in excess of 5 degrees.

(c) For aircraft having a maximum certificated take-off weight of 6,000 lbs. or less, the value specified in
subdivision (a) (2) (ii) of this section shall be 1.5 V s1 or, if the stalling speed V s1 is not obtainable in the particular
configuration, 1.5 times the minimum steady flight speed at which the airplane is controllable.

STABILITY

§ 3.113 General. The airplane shall be longitudinally, directionally, and laterally stable in accordance with the following sections. Suitable stability and control "feel" (static stability) shall be required in other conditions normally encountered in service, if flight tests show such stability to be necessary for safe operation.

§ 3.114 Static longitudinal stability. In the configurations outlined in § 3.115 and with the airplane trimmed as indicated, the characteristics of the elevator control forces and the friction within the control system shall be such that:

(a) A pull shall be required to obtain and maintain speeds below the specified trim speed and a push to obtain and maintain speeds above the specified trim speed. This shall be so at any speed which can be obtained without excessive control force, except that such speeds need not be greater than the appropriate maximum permissible speed or less than the minimum speed in steady unstalled flight.

(b) The air speed shall return to within 10 percent of the original trim speed when the control force is slowly released from any speed within the limits defined in paragraph (a) of this section.

§ 3.115 Specific conditions. In conditions set forth in this section, within the speeds specified, the stable slope of stick force versus speed curve shall be such that nay substantial change in speed is clearly perceptible to the pilot through a resulting change in stick force.

(a) Landing. The stick force curve shall have a stable slope and the stick force shall not exceed 40 lbs. at any speed between 1.1 Vs1 and 1.3 Vs1 with:

(1) Wing flaps in the landing position,

(2) The landing gear extended,

(3) Maximum weight,

(4) Throttles closed on all engines,

(5) The airplane trimmed at 1.4 Vs1 with throttles closed.

(b) Climb. The stick force curve shall have a stable slope at all speeds between 1.2 Vs1 and 1.6 Vs1 with:

(1) Wing flaps retracted,

(2) Landing gear retracted,

(3) Maximum weight,

(4) 75 percent of maximum continuous power,

(5) The airplane trimmed at 1.4 Vs1.

(c) Cruising. (1) Between 1.3 Vs1 and the maximum permissible speed, the stick force curve shall have a stable slope at all speeds obtainable with a stick force not in excess of 40 pounds with:

(i) Landing gear retracted,

(ii) Wing flaps retracted,

(iii) Maximum weight,

(iv) 75 percent of maximum continuous power,

(v) The airplane trimmed for level flight with 75 percent of the maximum continuous power.

(2) Same as subparagraph (1) of this paragraph, except that the landing gear shall be extended and the level flight trim speed need not be exceeded.

§ 3.116 Instrumented stick force measurements. Instrumented stick force measurements need not be made when changes in speed are clearly reflected by changes in stick forces and the maximum forces obtained in the above conditions are not excessive.

§ 3.117 Dynamic longitudinal stability. Any short period oscillation occurring between stalling speed and maximum permissible speed shall be heavily damped with the primary controls (1) free, and (2) in a fixed position.

§ 3.118 Directional and lateral stability—

(a) Three-control airplanes.

(1) The static directional stability, as shown by the tendency to recover from a skid with rudder free, shall be positive for all flap positions and symmetrical power conditions, and for all speeds from 1.2 Vs1 up to the maximum permissible speed.

(2) The static lateral stability as shown by the tendency to raise the low wing in a sideslip, for all flap positions and symmetrical power conditions, shall:

(i) Be positive at the maximum permissible speed.

(ii) Not be negative at a speed equal to 1.2 Vs1.

(3) In straight steady sideslips (unaccelerated forward slips), the aileron and rudder control movements and forces shall increase steadily, but not necessarily in constant proportion, as the angle of sideslip is increased; the rate of increase of the movements and forces shall lie between satisfactory limits up to sideslip angles considered appropriate to the operation of the type. At greater angles, up to that at which the full rudder control is employed or a rudder pedal force of 150 pounds is obtained, the rudder pedal forces shall not reverse and increased rudder deflection shall produce increased angles of sidelslip. Sufficient bank shall accompany sideslipping to indicate adequately any departure from steady unyawed flight.

(4) Any short-period oscillation occurring between stalling speed and maximum permissible speed shall be heavily damped with the primary controls (i) free and (ii) in a fixed position.

(b) Two-control (or simplified) airplanes.

(1) The directional stability shall be shown to be adequate by demonstrating that the airplane in all configurations can be rapidly rolled from a 45-degree bank to a 45-degree bank in the opposite direction without exhibiting dangerous skidding characteristics.

(2) Lateral stability shall be shown to be adequate by demonstrating that the airplane will not assume a dangerous attitude or speed when all the controls are abandoned for a period of 2 minutes. This demonstration shall be made in moderately smooth air with the airplane trimmed for straight level flight at 0.9 Vh (or at Vc, if lower), flaps and gear retracted, and with rearward center of gravity loading.

(3) Any short period oscillation occurring between the stalling speed and the maximum permissible speed shall be heavily damped with the primary controls (i) free and (ii) in a fixed position.

STALLS

§3.120 *Stalling demonstration.*

(a) Stalls shall be demonstrated under two conditions:

(1) With power off, and

(2) With the power setting not less than that required to show compliance with the provisions of paragraph (a) of § 3.85 or with those of § 3.85a, whichever are appropriate.

(b) In either condition required by paragraph (a) of this section it shall be possible, with flaps and landing gear in any position, with center of gravity in the position least favorable for recovery, and with appropriate airplane weights, to show compliance with the applicable requirements of paragraphs (c) through (f) of this section.

(c) For airplanes having independently controlled rolling and directional controls, it shall be possible to produce and to correct roll by unreversed use of the rolling control and to produce and correct yaw by unreversed use of the directional control up until the time the airplane pitches in the maneuver prescribed in paragraph (g) of this section.

(d) For two-control airplanes having either interconnected lateral and directional controls or for airplanes having only one of these controls, it shall be possible to produce and to correct roll by unreversed use of the rolling control without producing excessive yaw up until the time the airplane pitches in the maneuver prescribed in paragraph (g) of this section.

[(e) During the recovery portion of the maneuver, it shall be possible to prevent more than 15 degrees roll or yaw by the normal use of controls, and any loss of altitude in excess of 100 feet or any pitch in excess of 30 degrees below level shall be entered in the Airplane Flight Manual.**]**

(f) A clear and distinct ive stall warning shall precede the stalling of the airplane, with the flaps and landing gear in any position, both in straight and turning flight. The stall warning shall begin at a speed exceeding that of stalling by not less than 5 but not more than 10 miles per hour and shall continue until the stall occurs.

(g) In demonstrating the qualities required by paragraphs (c) through (f) of this section, the procedure set forth in subparagraphs (1) and (2) of this paragraph shall be followed.

(1) With trim controls adjusted for straight flight at a speed of approximately 1.4 V s1, the speed shall be reduced by means of the elevator control until the speed is steady at slightly above stalling speed; then

(2) The elevator control shall be pulled back at a rate such that the airplane speed reduction does not exceed 1 mile per hour per second until a stall is produced as evidenced by an uncontrollable downward pitching motion of the airplane, or until the control reaches the stop. Normal use of the elevator control for recovery shall be allowed after such pitching motion has unmistakably developed.

§ 3.121 Climbing stalls. When stalled from an excessive climb attitude it shall be possible to recover from this maneuver without exceeding the limiting air speed or the allowable acceleration limit.

§ 3.122 Turning flight stalls. When stalled during a coordinated 30-degree banked turn with 75 percent maximum continuous power on all engines, flaps and landing gear retracted, it shall be possible to recover to normal level flight without encountering excessive loss of altitude, uncontrollable rolling characteristics, or uncontrollable spinning tendencies. These qualities shall be demonstrated by performing the following maneuver: After a steady curvilinear level coordinated flight condition in a 30-degree bank is established and while maintaining the 30-degree bank, the airplane shall be stalled by steadily and progressively tightening the turn with the elevator control until the airplane is stalled or until the elevator has reached its stop. When the stall has fully developed, recovery to level flight shall be made with normal use of the controls.

§ 3.123 One-engine-inoperative stalls. Multiengine airplanes shall not display any undue spinning tendency and shall be safely recoverable without applying power to the inoperative engine when stalled with:

(a) The critical engine inoperative,

(b) Flaps and landing gear retracted,

(c) The remaining engines operating at up to 75 percent of maximum continuous power, except that the power need not be greater than that at which the use of maximum control travel just holds the wings laterally level in approaching the stall. The operating engines may be throttled back during the recovery from the stall.

SPINNING

§ 3.124 Spinning—

(a) Category N. All airplanes of 4,000 lbs. or less maximum weight shall recover from a one-turn spin with the controls applied normally for recovery in not more than one additional turn and without exceeding either the limiting air speed or the limit positive maneuvering load factor for the airplane. In addition, there shall be no excessive back pressure either during the spin or in the recovery. It shall not be possible to obtain uncontrollable spins by means of any possible use of the controls. Compliance with these requirements shall be demonstrated at any permissible combination of weight and center of gravity positions obtainable with all or any part of the designed useful load. All airplanes in category N, regardless of weight, shall be placarded against spins or demonstrated to be "characteristically incapable of spinning" in which case they shall be so designated. (See paragraph (d) of this section.)

(b) Category U. Airplanes in this category shall comply with either the entire requirements of paragraph (a) of this section or the entire requirements of paragraph (c) of this section.

(c) Category A. All airplanes in this category must be capable of spinning and shall comply with the following:

(1) At any permissible combination of weight and center of gravity position obtainable with all or part of the design useful load, the airplane shall recover from a six-turn spin with controls free in not more than four additional turns after releasing the controls. If the airplane will not recover as prescribed with controls free but will recover with the controls assisted to the extent necessary to overcome friction, the airplane may be certificated with the rearmost center of gravity position 2 percent forward of the position used in the test.

(2) It shall be possible to recover at any point in the spinning described above by using the controls in a normal manner for that purpose in not more than one and one-half additional turns, and without exceeding either the limiting air speed or the limit positive maneuvering load factor for the airplane. It shall not be possible to obtain uncontrollable spins by means of any possible use of the controls.

(d) Category NU. When it is desired to designate an airplane as a type "characteristically incapable of spinning," the flight tests to demonstrate this characteristic shall also be conducted with:

(1) A maximum weight 5 percent in excess of the weight for which approval is desired,

(2) A center of gravity at least 3 percent aft of the rearmost position for which approvals is desired,

(3) An available up-elevator travel 4 degrees in excess of that to which the elevator travel is to be limited by appropriate stops.

(4) An available rudder travel 7 degrees, in both directions, in excess of that to which the rudder travel is to be limited by appropriate stops.

GROUND AND WATER CHARACTERISTICS

§ 3.143 Requirements. All airplanes shall comply with the requirements of §§ 3.144 to 3.147.

§ 3.144 Longitudinal stability and control. There shall be no uncontrollable tendency for landplanes to nose over in any operating condition reasonably expected for the type, or when rebound occurs during landing or take-off. Wheel brakes shall operate smoothly and shall exhibit no undue tendency to induce nosing over. Seaplanes shall exhibit no dangerous or uncontrollable proposing at any speed at which the airplane is normally operated on the water.

§ 3.145 Directional stability and control.

(a) There shall be no uncontrollable looping tendency in 90-degree cross winds up to a velocity equal to 0.2 Vso at any speed at which the aircraft may be expected to be operated upon the ground or water.

(b) All landplanes shall be demonstrated to be satisfactorily controllable with no exceptional degree of skill or alternates on the part of the pilot in power-off landings at normal landing speed and during which brakes or engine power are not to maintain a straight path.

(c) Means shall be provided for adequate directional control during taxiing.

§ 3.146 Shock absorption. The shock absorbing mechanism shall not produce damage to the structure when the airplane is taxied on the roughest ground which it is reasonable to expect the airplane to encounter in normal operation.

§ 3.147 Spray characteristics. For seaplanes, spray during taxiing, take-off, and landing shall at no time dangerously obscure the vision of the pilots nor produce damage to the propeller or other parts of the airplane.

FLUTTER AND VIBRATION

§ 3.159 Flutter and vibration. All parts of the airplane shall be demonstrated to be free from flutter and excessive vibration under all speed and power conditions appropriate to the operation of the airplane up to at least the minimum valve permitted for Vd in § 3.184. There shall also be no buffeting condition in any normal flight condition severe enough to interfere with the satisfactory control of the airplane or to cause excessive fatigue to the crew or result in structural damage. However, buffeting as stall warning is considered desirable and discouragement of this type of buffeting is not intended.

SUBPART C—STRENGTH REQUIREMENTS
GENERAL

§ 3.171 Loads.

(a) Strength requirements are specified in terms of limit and ultimate loads. Limit loads are the maximum loads anticipated in service. Ultimate loads are equal to the limit loads multiplied by the factor of safety. Unless otherwise described, loads specified are limit loads.

(b) Unless otherwise provided, the specified air, ground, and water loads shall be placed in equilibrium with inertia forces, considering all items of mass in the airplane. All such loads shall be distributed in a manner conservatively approximating or closely representing actual conditions. If deflections under load would change significantly the distribution of external or internal loads, such redistribution shall be taken into account.

§ 3.172 Factor of safety. The factor of safety shall be 1.5 unless otherwise specified.

§ 3.173 Strength and deformations. The structure shall be capable of supporting limit loads without suffering detrimental permanent deformations. At all loads up to limit loads, the deformation shall be such as not to interfere with safe operation of the airplane. The structure shall be capable of supporting ultimate loads without failure for at least 3 seconds, except that when proof of strength is demonstrated by dynamic tests simulating actual conditions of load application, the 3-second limit does not apply

§ 3.174 Proof of structure. Proof of compliance of the structure with the strength and deformation requirements of § 3.173 shall be made for all critical loading conditions. Proof of compliance by means of structural analysis will be accepted only when the structure conforms with types for which experience has shown such methods to be reliable. In all other cases substantiating load tests are required. In all cases certain portions of the structure must be subjected to tests as specified in Subpart D.

FLIGHT LOADS

§ 3.181 General. Flight load requirements shall be complied with at critical altitudes within the range in which the airplane may be expected to operate and at all weights between the minimum design weight and the maximum design weight, with any practicable distribution of disposable load within prescribed operating limitations stated in § 3.777-3.780.

§ 3.182 Definition of flight load factor. The flight load factors specified represent the acceleration component (in terms of the gravitational constant g) normal to the assumed longitudinal axis of the airplane, and equal in magnitude and opposite in direction to the airplane inertia load factor at the center of gravity.

SYMMETRICAL FLIGHT CONDITIONS (FLAPS RETRACTED)

§ 3.183 General. The strength requirements shall be met at all combinations of air speed and load factor on and within the boundaries of a pertinent V-n diagram, constructed similarly to the one shown in Figure 3-1, which represents the envelope of the flight loading conditions specified by the maneuvering and gust criteria of §§ 3.185 and 3.187. This diagram will also be used in determining the airplane structural operating limitations as specified in Subpart G.

§ 3.184 Design air speeds. The design air speeds shall be chosen by the designer except that they shall not be less than the following values:

V_c (design cruising speed)

$= 38 \sqrt{W/S}$ (NU)

$= 42 \sqrt{W/S}$ (A)

except that for values of W/S greater than 20, the above numerical multiplying factors shall be decreased linearly with W/S to a value of 33 at W/S=100: And further provided, That the required minimum value need be no greater than
0.9 Vh actually obtained at sea level.

V_d (design dive speed)

$= 1.40\ V_c$ min (N)

$= 1.50\ V_c$ min (U)

$= 1.55\ V_c$ min (A)

except that for values of W/S greater than 20, the above numerical multiplying factors shall be decreased linearly with W/S to a value of 1.35 at W/S=100. (Vc min is the required minimum value of design cruising speed specified above.)

V_p (design maneuvering speed)

$= V_s \sqrt{n}$ where:

V_s = computed stalling speed with flaps fully retracted at the design weight, normally based on the maximum airplane normal force coefficient, C_{NA}.

N= limit maneuvering load factor used in design,

except that the value of Vp need not exceed the value of Vc used in design.

§ 3.185 Maneuvering envelope. The airplane shall be assumed to subjected to symmetrical maneuvers resulting in the following limit load factors, except where limited by maximum (static) lift coefficients:

(a) The positive maneuvering load factor specified in § 3.186 at all speeds up to Vd,

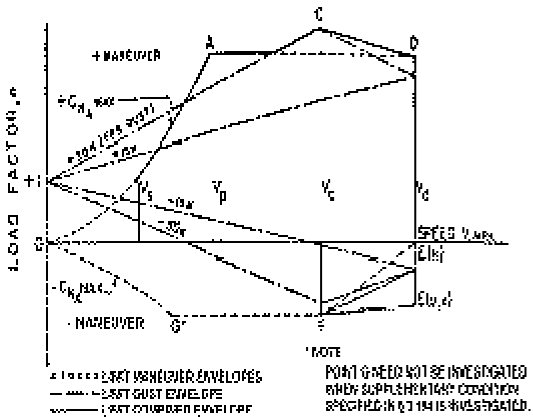


FIG. 3-2—(V-n) DIAGRAM (FLIGHT ENVELOPE)

(b) The negative maneuvering load factor specified in § 3.188 at speed Vc; and factors varying linearly with speed from the specified value at Vc to 0.0 at Vd for the N category and -1.0 at Vd for the A and U categories.

§ 3.186 Maneuvering load factors.

(a) The positive limit maneuvering load factors shall not be less than the following values (see Fig. 3-2):

$$n = 2.1 + \frac{24{,}000}{W + 10{,}000} \text{ -----------Category N}$$

except that n need not be greater than 3.8 and shall not be less than 2.5. For airplanes certificated as characteristically incapable of spinning, n need not exceed 3.5.

n = 4.4--------------------------------Category U
n = 6.0--------------------------------Category A

(b) The negative limit maneuvering load factors shall not be less than -0.4 times the positive load factor for the N and U categories, and shall not be less than -0.5 times the positive load factor for the A category.

(c) Lower values of maneuvering load factor may be employed only if it be proven that the airplane embodies features of design which make it impossible to exceed such values in flight. (See also § 3.106.)

§ 3.187 Gust envelope. The airplane shall be assumed to encounter symmetrical vertical gusts as specified below while in level flight and the resulting loads shall be considered limit loads:

(a) Positive (up) and negative (down) gusts of 30 feet per second nominal intensity at all speeds up to Vc,

(b) Positive and negative 15 feet per second gusts at Vd. Gust load factors shall be assumed to vary linearly between Vc and Vd.

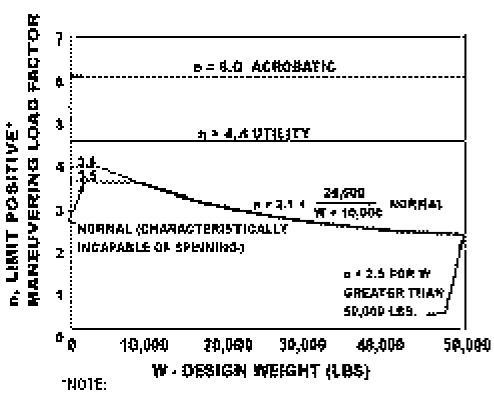
§ 3.188 Gust load factors. In applying the gust requirements, the gust load factors shall be computed by the following formula:

$$n = 1 + \frac{KUV_m}{575\,(W/S)}$$

where: $K = \frac{1}{2}(W/S)^{\frac{1}{4}}$ (for $W/S < 16$ p.s.f.)

$$= 1.33 - \frac{2.67}{(W/S)^{\frac{3}{4}}} \quad \text{(for } W/S > 16 \text{ p.s.f.)}$$

U = nominal gust velocity, f.p.s.
(Note that the "effective sharp-edged gust" equals KU.)
V = airplane speed, m.p.h.
m = slope of lift curve, CL per radian, corrected for aspect ratio.
W/S = wing loading, p.s.f.



*NOTE: LIMIT NEGATIVE MANEUVERING LOAD FACTORS SHALL BE OBTAINED BY MULTIPLYING THE POSITIVE FACTOR VALUES BY .4 FOR NORMAL AND UTILITY CATEGORIES AND BY .5 FOR THE ACROBATIC CATEGORY.

FIG. 3-2—LIMIT MANEUVERING LOAD FACTORS

§ 3.189 Airplane equilibrium. In determining the wing loads and linear inertia loads corresponding to any of the above
specified flight conditions, the appropriate balancing horizontal tail load (see § 3.215) shall be taken into account in a rational or conservative manner. Incremental horizontal tail loads due to maneuvering and gusts (see §§ 3.216 and 3.217) shall be reacted by angular inertia of the complete airplane in a rational or conservative manner.

FLAPS EXTENDED FLIGHT CONDITIONS

§ 3.190 Flaps extended flight conditions.

(a) When flaps or similar high lift devices intended for use at the relatively low air speeds of approach, landing, and take-off are installed, the airplane shall be assumed to be subjected to symmetrical maneuvers and gusts with the flaps fully deflected at the design flap speed Vf resulting in limit load factors within the range determined by the following conditions:

(1) Maneuvering, to a positive limit load factor of 2.0.

(2) Positive and negative 15-feet-per-second gusts acting normal to the flight path in level flight. The gust load factors shall be computed by the formula of § 3.188.

Vf shall be assumed not less than 1.4 Vs of 1.8 Vsf whichever is greater, where:

Vs = the computed stalling speed with flaps fully retracted at the design weight

Vsf = the computed stalling speed with flaps fully extended at the design weight except that when an automatic flap load limiting device is employed, the airplane may be designed for critical combinations of air speed and flap position permitted by the device. (See also § 3.338.)

(b) In designing the flaps and supporting structure, slipstream effects shall be taken into account as specified in § 3.223.

Note: In determining the external loads on the airplane as a whole, the thrust, slip-stream, and pitching acceleration may be assumed equal to zero.

UNSYMMETRICAL FLIGHT CONDITIONS

§ 3.191 Unsymmetrical flight conditions. The airplane shall be assumed to be subjected to rolling and yawing maneuvers as described in the following conditions. Unbalanced aerodynamic moments about the center of gravity shall be reacted in a rational or conservative manner considering the principal masses furnishing the reacting inertia forces.

(a) Rolling conditions. The airplane shall be designed for (1) unsymmetrical wing loads appropriate to the category, and (2) the loads resulting from the aileron deflections and speeds specified in § 3.222, in combination with an airplane load factor of at least two-thirds of the positive maneuvering factor used in the design of the airplane. Only the wing and wing bracing need be investigated for this condition.

Note: These conditions may be covered as noted below:

(a) Rolling accelerations may be obtained by modifying the symmetrical flight conditions shown in Figure 3-1 as follows:

(1) Acrobatic category. In conditions A and F assume 100 percent of the wing air load acting on one side of the plane of symmetry and 60 percent on the other.

(2) Normal and utility categories. In condition A, assume 100 percent of the wing air load acting on one side of the airplane and 70 percent on the other. For airplanes over 1,000 pounds design weight, the latter percentage may be increased linearly with weight up to 80 percent at 25,000 pounds.

(b) The effect of aileron displacement on wing torsion may be accounted for by adding the following increment to the basic airfoil moment coefficient over the aileron portion of the span in the critical condition as determined by the note under § 3.222:

$$\Delta_{cm} = -.01\delta$$

where:

Δ_{cm} = moment coefficient increment

δ = down aileron deflection in degrees in critical condition

(b) Yawing conditions. The airplane shall be designed for the yawing loads resulting from the vertical surface loads specified in §§ 3.219 to 3.221.

SUPPLEMENTARY CONDITIONS

§ 3.194 Special condition for rear lift truss. When a rear lift truss is employed, it shall be designed for conditions of reversed airflow at a design speed of:

$$V = 10\sqrt{W/S} \div 10 \text{ (m.p.h.)}$$

Note: It may be assumed that the value of CL is equal to -0.8 and the chordwise distribution is triangular between a peak at the trailing edge and zero at the leading edge.

§ 3.195 Engine torque effects.

(a) Engine mounts and their supporting structures shall be designed for engine torque effects combined with
certain basic flight conditions as described in subparagraphs (1) and (2) of this paragraph. Engine torque may be neglected in the other flight conditions.

(1) The limit torque corresponding to takeoff power and propeller speed acting simultaneously with 75 percent of the limit loads from flight condition A. (See Fig. 3-1.)

(2) The limit torque corresponding to maximum continuous power and propeller speed, acting simultaneously with the limit loads from flight condition A. (See Fig. 3-1.)

(b) The limit torque shall be obtained by multiplying the mean torque by a factor of 1.33 in the case of engines having 5 or more cylinders. For 4-, 3-, and 2-cylinder engines, the factor shall be 2, 3, and 4, respectively.

§ 3.196 Side load on engine mount. The limit load factor in a lateral direction for this condition shall be at least equal to one-third of the limit load factor for flight condition A (see Fig. 3-1) except that it shall not be less than 1.33. Engine mounts and their supporting structure shall be designed for this condition which may be assumed independent of other flight conditions.

CONTROL SURFACE LOADS

§ 3.211 General. The control surface loads specified in the following sections shall be assumed to occur in the symmetrical and unsymmetrical flight conditions as described in §§ 3.189-3.191. See Figures 3-3 to 3-10 for acceptable values of control surface loadings which are considered as conforming to the following detailed rational requirements.

§ 3.212 Pilot effort. In the control surface loading conditions described, the airloads on the movable surfaces and the corresponding deflections need not exceed those which could be obtained in flight by employing the maximum pilot control forces specified in Figure 3-11. In applying this criterion, proper consideration shall be given to the effects of control system boost and servo mechanisms, tabs, and automatic pilot systems in assisting the pilot.

§ 3.213 Trim tab effects. The effects of trim tabs on the control surface design conditions need be taken into account only in cases where the surface loads are limited on the basis of maximum pilot effort. In such cases the tabs shall be considered to be deflected in the direction which would assist the pilot and the deflection shall correspond to the maximum expected degree of "out of trim" at the speed for the condition under consideration.

HORIZONTAL TAIL SURFACES

§ 3.214 Horizontal tail surfaces. The horizontal tail surfaces shall be designed for the conditions set forth in §§ 3.215-3.218.

§ 3.215 Balancing loads. A horizontal tail balancing load is defined as that necessary to maintain the airplane in equilibrium in a specified flight condition with zero pitching acceleration. The horizontal tail surfaces shall be designed for the balancing loads occurring at any point on the limit maneuvering envelope, Figure 3-1, and in the flap conditions. (See § 3.190.)

Note: The distribution of Figure 3-7 may be used.

§ 3.216 Maneuvering loads.

(a) At maneuvering speed Vp assume a sudden deflection of the elevator control to the maximum upward deflection as limited by the control stops or pilot effort, whichever is critical.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-8 may be used. In determining the resultant normal force coefficient for the tail under these conditions, it will be permissible to assume that the angle of attack of the stabilizer with respect to the resultant direction of air flow is equal to that which occurs when the airplane is in steady unaccelerated flight at a flight speed equal to Vp. The maximum elevator deflection can then be determined from the above criteria and the tail normal force coefficient can be obtained from the data given in NACA Report No. 688, "Aerodynamic Characteristics of Horizontal Tail Surfaces," or other applicable NACA reports.

(b) Same as case (a) except that the elevator deflection is downward.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-8 may be used.

(c) At all speeds above Vp the horizontal tail shall be designed for the maneuvering loads resulting from a sudden upward deflection of the elevator, followed by a downair deflection of the elevator such that the following combinations of normal acceleration and angular acceleration are obtained:

Condition	Airplane normal acceleration n	Angular acceleration radian/sec.^{2}
Down load	1.0	$+\frac{[illegible]}{V} n_m (n - 1.5)$
Up load	n_m	$-\frac{[illegible]}{V} n_m (n_m - 1.5)$

Acceptable values of limit average maneuvering control surface loadings can be obtained from Figure 3-3 (b) as follows:

HORIZONTAL TAIL SURFACES

(1) Condition § 3.216 (a):

Obtain $\bar{w}$ as function of W/S and surface deflection;

Use Curve C for deflection 10° or less;

Use Curve B for deflection 20°;

Use Curve A for deflection 30° or more;

(Interpolate for other deflections);

Use distribution of Figure 3-8.

(2) Condition § 3.216 (b):

Obtain $\bar{w}$ from Curve B. Use distribution of Figure 3-8.

VERTICAL TAIL SURFACES

(3) Condition § 3.219 (a):

Obtain $\bar{w}$ as function of W/S and surface deflection in same manner as outlined in (1) above, use distribution of Figure 3-8;

(4) Condition § 3.219 (b):

Obtain $\bar{w}$ from Curve C, use distribution of Figure 3-7;

(5) Condition § 3.219 (c):

Obtain $\bar{w}$ from Curve A, use distribution of Figure 3-9. (Note that condition § 3.220 generally will be more critical than this condition.)

AILERONS

(6) In lieu of conditions § 3.222 (b):

Obtain $\bar{w}$ from Curve B, acting in both up and down directions. Use distribution of Figure 3-10. where:

n_m = positive limit maneuvering load factor used in the design of the airplane.
V = initial speed in miles per hour.

FIG. 3-3(a)—LIMIT AVERAGE MANEUVERING CONTROL SURFACE LOADINGS

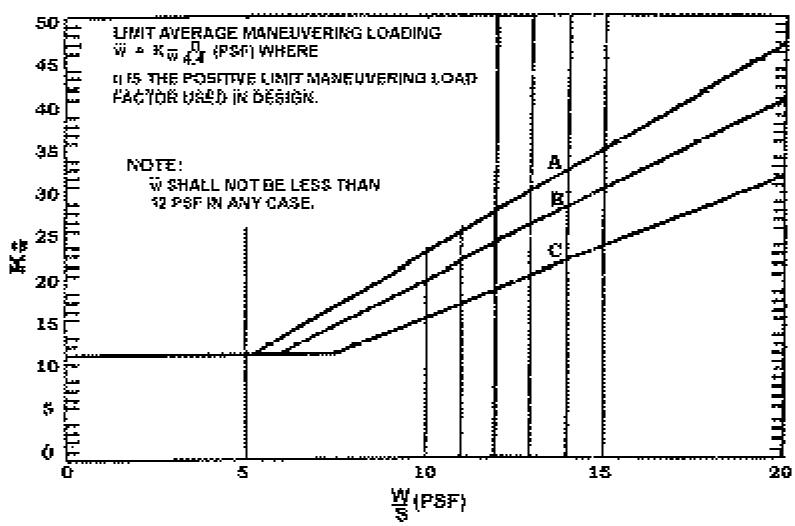


FIGURE 3-3(b) —LIMIT AVERAGE MANEUVERING CONTROL SURFACE LOADING

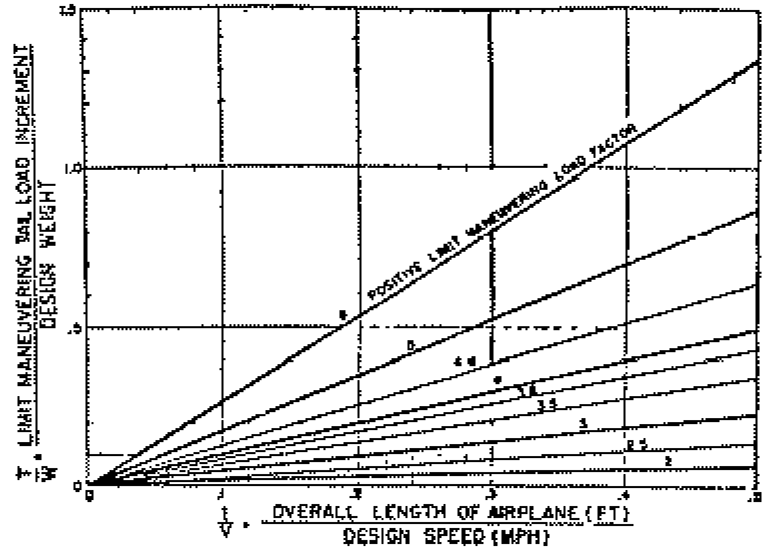


FIG. 3-4 —— MANEUVERING TAIL LOAD INCREMENT (UP OR DOWN)

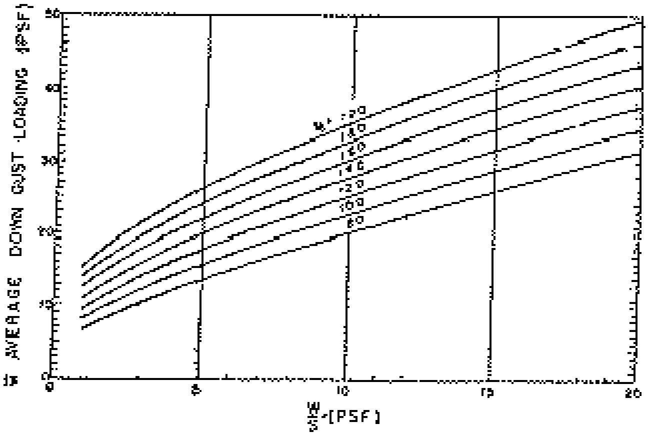


FIG. 3-5(a)—DOWN GUST LOADING ON HORIZONTAL TAIL SURFACE

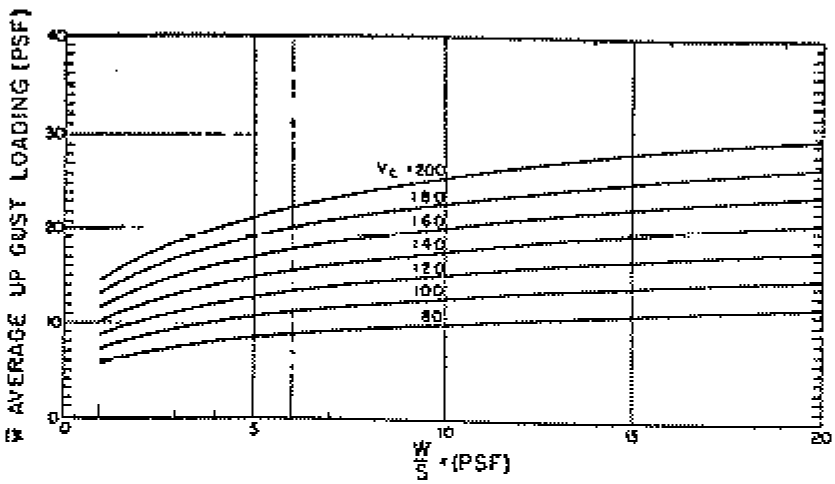


FIG. 3-5(b)—UP GUST LOADING ON HORIZONTAL TAIL SURFACE

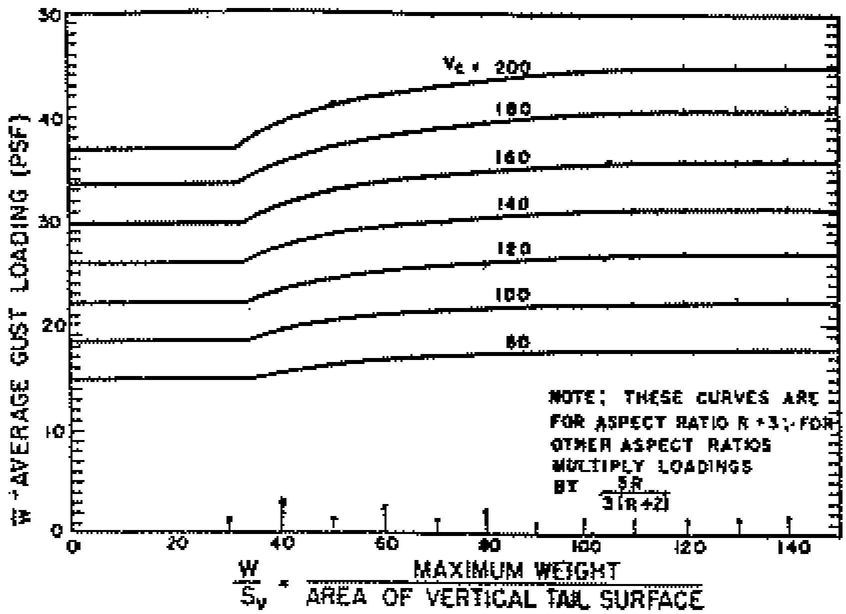
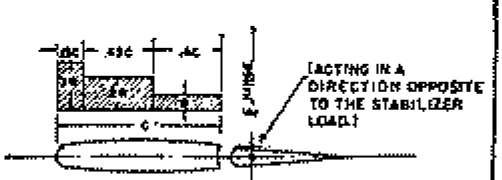


FIG. 3-6 —— GUST LOADING ON VERTICAL TAIL SURFACE



NOTES:
(a) IN BALANCING CONDITIONS 03.22II
P = 40% OF NET BALANCING LOAD
(FLAPS RETRACTED)
P = 0 (FLAPS DEFLECTED)
(b) IN CONDITION 03.222(b)
P = 20% OF NET TAIL LOAD

FIG. 3-7 TAIL SURFACE LOAD DISTRIBUTION

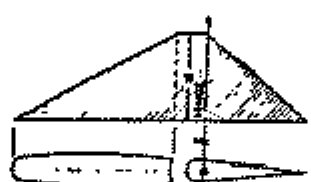


FIG. 3-8 TAIL SURFACE LOAD DISTRIBUTION

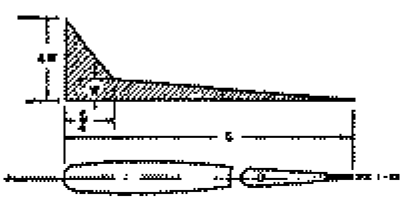


FIG. 3-9 TAIL SURFACE LOAD DISTRIBUTION

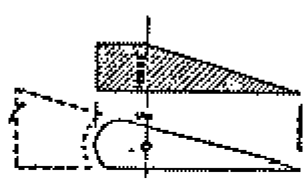


FIG. 3-10 AILERON LOAD DISTRIBUTION

(d) The total tail load for the conditions specified in (c) shall be the sum of: (1) The balancing tail load corresponding with the condition at speed V and the specified value of the normal load factor n, plus (2) the maneuvering load increment due to the specified value of the angular acceleration.

NOTE: The maneuvering load increment of Figure 3-4 and the distributions of Figure 3-8 (for downloads) and Figure 3-9 (for uploads) may be used. These distributions apply to the total tail load.

§ 3.217 Gust loads. The horizontal tail surfaces shall be designed for loads occurring in the following conditions:

(a) Positive and negative gusts of 30 feet per second nominal intensity at speed Vc, corresponding to flight condition § 3.187 (a) with flaps retracted.

NOTE: The average loadings of Figures 3-5 (a) and 3-5 (b) and the distribution of Figure 3-9 may be used for the total tail loading in this condition.

(b) Positive and negative gusts of 15 feet per second nominal intensity at speed Vt, corresponding to flight condition § 3.190 (b) with flaps extended. In determining the total load on the horizontal tail for these conditions, the initial balancing tail loads shall first be determined for steady unaccelerated flight at the pertinent design speeds Vc and Vt. The incremental tail load resulting from the gust shall then be added to the initial balancing tail load to obtain the total tail load.

Note: The incremental tail load due to the gust may be computed by the following formula:

$$\Delta^{t} = 0.1\ KUVS_t a_t \left(1 - \frac{36 a_w}{R_w}\right)$$

where:

Δ^{t} = the limit gust load increment on the tail in pounds;
K = gust coefficient K in § 3.188,
U = nominal gust intensity in feet per second,
V = airplane speed in miles per hour,
St = tail surface area in square feet,
at = slope of lift curve of tail surface,
CL per degree, corrected for aspect ratio,
aw = slope of lift curve of wing, CL per degree,
Rw = aspect ratio of the wing.

§ 3.218 Unsymmetrical loads. The maximum horizontal tail surface loading (load per unit area), as determined by the preceding sections, shall be applied to the horizontal surfaces on one side of the plane of symmetry and the following percentage of that loading shall be applied on the opposite side:

% = 100-10 (n-1) where:

n is the specified positive maneuvering load factor.

In any case the above value shall not be greater than 80 percent.

VERTICAL TAIL SURFACES

§ 3.219 Maneuvering loads. At all speeds up to Vp:

(a) With the airplane in unaccelerated flight at zero yaw, a sudden displacement of the rudder control to the maximum deflection as limited by the control stops or pilot effort, whichever is critical, shall be assumed.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-8 may be used.

(b) The airplane shall be assumed to be yawned to a sideslip angle of 15 degrees while the rudder control is maintained at full deflection (except as limited by pilot effort) in the direction tending to increase the sideslip.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-7 may be used.

(c) The airplane shall be assumed to be yawed to a sideslip angle of 15 degrees while the rudder control is maintained in the neutral position (except as limited by pilot effort). The assumed sideslip angles may be reduced if is shown that the value chosen for a particular speed cannot be exceeded in the cases of steady slips, uncoordinated rolls from a steep bank, and sudden failure of the critical engine with delayed corrective action.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-9 may be used.

§ 3.220 Gust loads.

(a) The airplane shall be assumed to encounter a gust of 30 feet per second nominal intensity, normal to the plane of symmetry while in unaccelerated flight at speed Vc.

(b) The gust loading shall be computed by the following formula:

$$\bar{w} = \frac{KUVm}{575}$$

where:

$\bar{w}$ = average limit unit pressure in pounds per square foot,

K = $1.33 - \frac{4.5}{(W/S_v)^{3/4}}$ except that K shall not be less than 1.0. A value of K obtained by rational determination may be used.

U = nominal gust intensity in feet per second,

V = airplane speed in miles per hour,

m = slope of lift curve of vertical surface, CL per radian, corrected for aspect ratio,

W = design weight in pounds,

Sv = vertical surface area in square feet.

(c) This loading applies only to that portion of the vertical surfaces having a well-defined leading edge.

Note: The average loading of Figure 3-6 and the distribution of Figure 3-9 may be used.

§ 3.221 Outboard fins. When outboard fins are carried on the horizontal tail surface, the tail surfaces shall be designed for the maximum horizontal surface load in combination with the corresponding loads induced on the vertical surfaces by end plate effects. Such induced effects need not be combined with other vertical surface loads. When outboard fins extend above and below the horizontal surface, the critical vertical surface loading (load per unit area) as determined by §§ 3.219 and 3.220 shall be applied:

(a) To the portion of the vertical surfaces above the horizontal surface, and 80 percent of that loading applied to the portion below the horizontal surface,

(b) To the portion of the vertical surfaces below the horizontal surface, and 80 percent of that loading applied to the portion above the horizontal surface.

AILERONS, WING FLAPS, TABS, ETC.

§ 3.222 Ailerons.

(a) In the symmetrical flight conditions (see §§ 3.183-3.189), the ailerons shall be designed for all loads to which they are subjected while in the neutral position.

(b) In unsymmetrical flight conditions (see § 3.191 (a)), the ailerons shall be designed for the loads resulting from the following deflections except as limited by pilot effort:

(1) At speed Vp it shall be assumed that there occurs a sudden maximum displacement of the aileron control. (Suitable allowance may be made for control system deflections.)

(2) When Vc is greater than Vp, the aileron deflection at Vc shall be that required to produce a rate of roll not less than that obtained in condition (1).

(3) At speed Vd the aileron deflection shall be that required to produce a rate of roll not less than one-third of that which would be obtained at the speed and aileron deflection specified in condition (1).

Note: For conventional ailerons, the deflections for conditions (2) and (3) may be computed from:

$\delta_2 = \frac{V_p}{V_c}\delta_1$ and $\delta_3 = \frac{.5V_p}{V_d}\delta_1$

where:

δ_1 = total aileron deflection (sum of both aileron deflections) in condition (1).

δ_2 = total aileron deflection in condition (2).

δ_3 = total deflection in condition (3). In the equation for δ_3 the 0.5 factor is used instead of 0.33 to allow for wing torsional flexibility.

(c) The critical loading on the ailerons should occur in condition (2) if Vd is less than 2Vc and the wing meets the torsional stiffness criteria. The normal force coefficient CN for the ailerons may be taken as 0.04δ, where δ is the deflection of the individual aileron in degrees. The critical condition for wing torsional loads will depend upon the basic airfoil moment coefficient as well as the speed, and may be determined as follows:

$$\frac{T_3}{T_2} = \frac{(C_m - .01\,\delta_{3d})\,V_d^2}{(C_m - .01\,\delta_{2d})\,V_c^2}$$

where:

T3/T2 is the ratio of wing torsion in condition (b) (3) to that in condition (b) (2).

δ_{2d} *and* δ_{3d} are the down deflections of the individual aileron in conditions (b) (2) and (3) respectively.

(d) When T3/T2 is greater than 1.0 condition (b) (3) is critical; when T3/T2 is less than 1.0 condition (b) (2) is critical.

(e) In lieu of the above rational conditions the average loading of Figure 3-3 and the distribution of Figure 3-10 may be used.

§ 3.223 Wing flaps. Wing flaps, their operating mechanism, and supporting structure shall be designed for critical loads occurring in the flap-extended flight conditions (see § 3.190) with the flaps extended to any position from fully retracted to fully extended; except that when an automatic flap load limiting device is employed these parts may be designed for critical combinations of air speed and flap position permitted by the device. (Also see §§ 3.338 and 3.339.) The effects of propeller slipstream corresponding to take-off power shall be taken into account at an airplane speed of not less than 1.4 Vs where Vs is the computed stalling speed with flaps fully retracted at the design weight.
For investigation of the slipstream condition, the airplane load factor may be assumed to be 1.0.

§ 3.224 Tabs. Control surface tabs shall be designed for the most severe combination of air speed and tab deflection likely to be obtained within the limit V-n diagram (Fig. 3-1) for any usable loading condition of the airplane.

§ 3.225 Special devices. The loading for special devices employing aerodynamic surfaces, such as slots and spoilers, shall be based on test data.

CONTROL SYSTEM LOADS

§ 3.231 Primary flight controls and systems.

(a) Flight control systems and supporting structure shall be designed for loads corresponding to 125 percent of the computed hinge moments of the movable control surface in the conditions prescribed in §§ 3.211 to 3.225, subject to the following maxima and minima:

(1) The system limit loads need not exceed those which can be produced by the pilot and automatic devices operating the controls.

(2) The loads shall in any case be sufficient to provide a rugged system for service use, including consideration of jamming, ground gusts, taxiing tail to wind, control inertia, and friction.

(b) Acceptable maximum and minimum pilot loads for elevator, aileron, and rudder controls are shown in Figure 3-11. These pilot loads shall be assumed to act at the appropriate control grips or pads in a manner simulating flight conditions and to be reacted at the attachments of the control system to the control surface horn.

§ 3.232 Dual controls. When dual controls are provided, the systems shall be designed for the pilots operating in opposition, using individual pilot loads equal to 75 percent of those obtained in accordance with § 3.231, except that
the individual pilot loads shall not be less than the minimum loads specified in Figure 3-11.

§ 3.233 Ground gust conditions.

(a) The following ground gust conditions shall be investigated in cases where a deviation from the specific values for minimum control forces listed in Figure 3-11 is applicable. The following conditions are intended to simulate the loadings on control surfaces due to ground gusts and when taxiing with the wind.

(b) The limit hinge moment H shall be obtained from the following formula:

$H = KcSq$

where:

H = limit hinge moment (foot-pounds).

c = mean chord of the control surface aft of the hinge line (feet).

S = area of control surface aft of the hinge line (square feet).

q = dynamic pressure (pounds per square foot) to be based on a design speed not less than $10\sqrt{W/S}+10$ miles per hour, except that the design speed need not exceed 60 miles per hour.

K = factor as specified below:

Surface	K
(a) Aileron---Control column locked or lashed in midposition.	+ 0.75
(b) Aileron---Ailerons at full throw; + moment on one aileron, - moment on the other.	±0.50
(c) (d) Elevator---Elevator (c) full up (-), and (d) full down(+).	±0.75
(e) (f) Rudder---Rudder (e) in neutral, and (f) at full throw.	±0.75

(c) As used in paragraph (b) in connection with ailerons and elevators, a positive value of K indicates a moment tending to depress the surface while a negative value of K indicates a moment tending to raise the surface.

§ 3.234 Secondary controls and systems. Secondary controls, such as wheel brakes, spoilers, and tab controls, shall be designed for the loads based on the maximum which a pilot is likely to apply to the control in question.

GROUND LOADS

§ 3.241 Ground loads. The loads specified in the following conditions shall be considered as the external loads and inertia forces which would occur in an airplane structure if it were acting as a rigid body. In each of the ground load conditions specified the external reactions shall be placed in equilibrium with the linear and angular inertia forces in a rational or conservative manner.

§ 3.242 Design weight. The design weight used in the landing conditions shall not be less than the maximum weight for which certification is desired: Provided, however, That for multiengine airplanes meeting the one-engine inoperative climb requirement of § 3.85 (b), the airplane may be designed for a design landing weight which is less than the maximum design weight, if compliance is shown with the following sections of Part 4b in lieu of the corresponding requirements of this part: the ground load requirements of § 4b.241, and shock absorption requirements of § 4b.371 and its related sections, the wheel and tire requirements of §§ 4b.391 and 4b.392, and the fuel jettisoning system requirements of § 4b.536.

§ 3.243 Load factor for landing conditions. In the following landing conditions the limit vertical inertia load factor at the center of gravity of the airplane shall be chosen by the designer but shall not be less than the value which would
be obtained when landing the airplane with a descent velocity, in feet per second, equal to the following value:

$$V = 4.4 (W/S)^{1/4}$$

except that the descent velocity need not exceed 10 feet per second and shall not be less than 7 feet per second. Wing lift not exceeding two thirds of the weight of the airplane may be assumed to exist throughout the landing impact and may be assumed to act through the airplane center of gravity. When such wing lift is assumed, the ground reaction load factor may be taken equal to the inertia load factor minus the ratio of the assumed wing lift to the airplane weight. (See § 3.354 for requirements concerning the energy absorption tests which determine the limit load factor corresponding to the required limit descent velocities.) In no case, however, shall the inertia load factor used for design purposes be less than 2.67, nor shall the limit ground reaction load factor be less than 2.0, unless it is demonstrated that lower values of limit load factor will not be exceeded in taxiing the airplane over terrain having the maximum degree of roughness to be expected under intended service use at all speeds up to take-off speed.

LANDING CASES AND ATTITUDES

§ 3.244 Landing cases and attitudes. For conventional arrangements of main and nose, or main and tail wheels, the airplane shall be assumed to contact the ground at the specified limit vertical velocity in the attitudes described in
§§ 3.245-3.247. (See Figs. 3-12 (a) and 3-12 (b) for acceptable landing conditions which are considered to conform with §§ 3.245-3.247.)

§ 3.245 Level landing—

(a) Tail wheel type.Normal level flight attitude.

(b) Nose wheel type. Two cases shall be considered:

(1) Nose and main wheels contacting the ground simultaneously,

(2) Main wheels contacting the ground, nose wheel just clear of the ground. (The angular attitude may be assumed the same as in subparagraph (1) of this paragraph for purposes of analysis.)

(c) Drag components. In this condition, drag components simulating the forces required to accelerate the tires and wheels up to the landing speed shall be properly combined with the corresponding instantaneous vertical ground
reactions. The wheel spin-up drag loads may be based on vertical ground reactions, assuming wing lift and a tire-sliding coefficient of friction of 0.8, but in any case the drag loads shall not be less than 25 percent of the maximum vertical ground reactions neglecting wing lift.

LIMIT PILOT LOADS

Control	Maximum loads for design weight W equal to or less than 5,000 lbs.[1]	Minimum loads.[2]
Aileron:		
Stick	67 pounds	40 pounds.
Wheel[3]	53 D in-pounds[4]	40 D in-pounds
Elevator:		
Stick	167 pounds	100 pounds.
Wheel	200 pounds	100 pounds.
Rudder	200 pounds	130 pounds.

[1]For design weight W greater than 5,000 pounds the above specified maximum values shall be increased linearly with weight to 1.5 times the specified values at a design weight of 25,000 pounds.

[2]If the design of any individual set of control systems or surfaces is such as to make these specified minimum loads inapplicable, values corresponding to the pertinent binge moments obtained according to § 3.233 may be used instead, except that in any case values less than 0.6 of the specified minimum loads shall not be employed.

[3]The critical portions of the aileron control system shall also be designed for a single tangential force having a limit value equal to 1.25 times the couple force determined from the above criteria.

[4]D = wheel diameter.

FIG. 3-11 —PILOT CONTROL FORCE LIMITS

§ 3.246 Tail down—

(a) Tail wheel type. Main and tail wheels contacting ground simultaneously.

(b) Nose wheel type. Stalling attitude or the maximum angle permitting clearance of the ground by all parts of the airplane, whichever is the lesser.

(c) Vertical ground reactions. In this condition, it shall be assumed that the ground reactions are vertical, the wheels having been brought up to speed before the maximum vertical load is attained.

§ 3.247 One-wheel landing. One side of the main gear shall contact the ground with the airplane in the level attitude. The ground reactions shall be the same as those obtained on the one side in the level attitude. (See § 3.245.)

GROUND ROLL CONDITIONS

§ 3.248 Braked roll. The limit vertical load factor shall be 1.33. The attitude and ground contacts shall be those described for level landings in § 3.245, with the shock absorbers and tires deflected to their static positions. A drag reaction equal to the vertical reaction at the wheel multiplied by a coefficient of friction of 0.8 shall be applied at the ground contact point of each wheel having brakes, except that the drag reaction need not exceed the maximum value based on limiting brake torque.

§ 3.249 Side load. Level attitude with main wheels only contacting the ground, with the shock absorbers and tires deflected to their static positions. The limit vertical load factor shall be 1.33 with the vertical ground reaction divided equally between main wheels. The limit side inertia factor shall be 0.83 with the side ground reaction divided between main wheels as follows:
0.5 W acting inboard on one side.
0.33 W acting outboard on the other side.

TAIL WHEELS

§ 3.250 Supplementary conditions for tail wheels. The conditions in §§ 3.251 and 3.252 apply to tail wheels and affected supporting structure.

§ 3.251 Obstruction load. The limit ground reaction obtained in the tail down landing condition shall be assumed to act up and aft through the axle at 45 degrees. The shock absorber and tire may be assumed deflected to their static positions.

§ 3.252 Side load. A limit vertical ground reaction equal to the static load on the tail wheel, in combination with a side component of equal magnitude. When a swivel is provided, the tail wheel shall be assumed swiveled 90 degrees to the airplane longitudinal axis, the resultant ground load passing through the axle. When a lock steering device or shimmy damper is provided, the tail wheel shall also be assumed in the trailing position with the side load acting at the ground contact point. The shock absorber and tire shall be assumed deflected to their static positions.

NOSE WHEELS

§ 3.253 Supplementary conditions for nose wheels. The conditions set forth in §§ 3.254-3.256 apply to nose wheels and affected supporting structure. The shock absorbers and tires shall be assumed deflected to their static positions.

§ 3.254 Aft load. Limit force components at axle:

Vertical, 2.25 times static load on wheel, Drag, 0.8 times vertical load.

§ 3.255 Forward load. Limit force components at axle:

Vertical, 2.25 times static load on wheel,
Forward, 0.4 times vertical load.

§ 3.256 Side load. Limit force components at ground contact:

Vertical, 2.25 times static load on wheel, Side, 0.7 times vertical load.

SKIPLANES

§ 3.257 Supplementary conditions for skiplanes. The airplane shall be assumed resting on the ground with one main ski frozen in the snow and the other main ski and the tail ski free to slide. A limit side force equal to P/3 shall be
applied at the most convenient point near the tail assembly, where P is the static ground reaction on the tail ski. For this condition the factor of safety shall be assumed equal to 1.0.

WATER LOADS

§ 3.265 General. The requirements set forth in §§ 3.266-3.282 shall apply to the entire airplane, but have particular reference to hull structure, wing, nacelles, and float supporting structure.

DESIGN WEIGHT

§ 3.266 Design weight. The design weight used in the water landing conditions shall not be less than the maximum weight for which certification is desired for any operation.

BOAT SEAPLANES

§ 3.267 Local bottom pressures—

(a) Maximum local pressure. The maximum value of the limit local pressure shall be determined from the following equation:

$$P_{max} = 0.066\, V_{s_0}^{1.4} \left(1 + \frac{W}{60000}\right)^{1/4}$$

where
P = pressure in pound per square inch.

V_{s0} = stalling speed, flaps down, power off, in miles per hour (to be calculated on the basis of wind tunnel data or flight tests on previous airplanes).

W = design weight.

(b) Variation in local pressure. The local pressures to be applied to the hull bottom shall vary in accordance with Figure 3-13. No variation from keel to chine (beamwise) shall be assumed, except when the chine flare indicates the advisability of higher pressures at the chine.

Condition	Tail wheel type: Level landing	Tail wheel type: Tail-down landing	Nose wheel type: Level landing with inclined reactions	Nose wheel type: Level landing with nose wheel just clear of ground	Nose wheel type: Tail-down landing
Reference section-----	§3.245(a)	§3.246(a)	§ 3.245 (b) (1)	§ 3.245 (b) (2)	§ 3.246 (b) (c)
Vertical component at c.g---------------------	nW	nW	nW	nW	nW
Fore and aft component at c.g.-----------------	KnW	0	KnW	KnW	0
Lateral component in either direction at c.g.	0	0	0	0	0
Shock absorber extension (hydraulic shock absorber)--------	Note (2)	Note (2)	Note (2)	Note (2)	Note (2)
Shock absorber deflection (rubber or spring shock absorber)---------------	100%	100%	100%	100%	100%
Tire deflection------------	Static	Static	Static	Static	Static
Main wheel loads (both wheels)-------------(V_r	nW	nWb/d	nWb'/d'	nW	nW
(D_r	KV_r	0	KV_r	KV_r	0
Tail (nose) wheel loads ----------------------(V_f	0	nWa/d	nWa'/d'	0	0
(D_f	0	0	KV_f	0	0
Notes---------------------	(1) and (3)	--------------	(1)	(1) and (3)	(3)

Note (1).—K may be determined as follows: K=0.25 for W=3,000 pounds or less; K=0.33 for W=6,000 pounds or greater with linear variation of K between these weights.

Note (2).—For the purpose of design, the maximum load factor shall be assumed to occur throughout the shock absorber stroke from 25 percent deflection to 100 percent deflection unless demonstrated otherwise, and the load factor shall be used with whatever shock absorber extension is most critical for each element of the landing gear.

Note (3).—Unbalanced moments shall be balanced by a rational or conservative method.

FIG. 3-12(a)—BASIC LANDING CONDITIONS

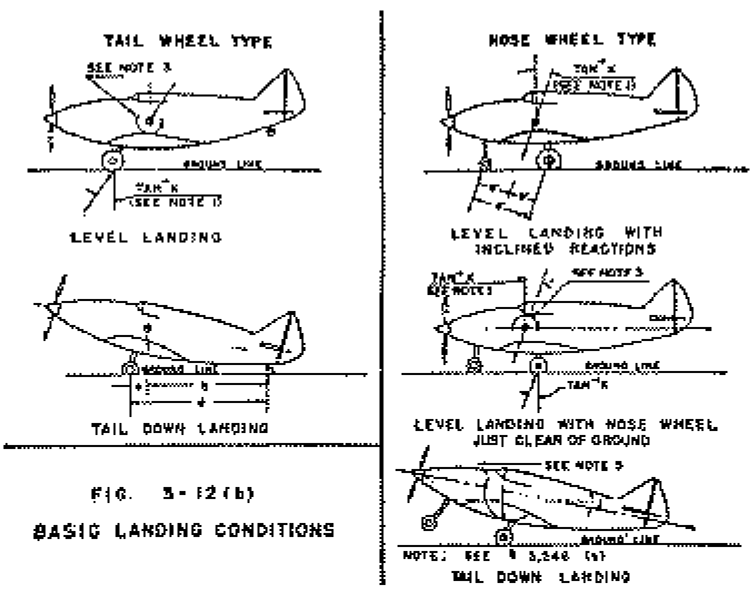


FIG. 3-12(b)

BASIC LANDING CONDITIONS

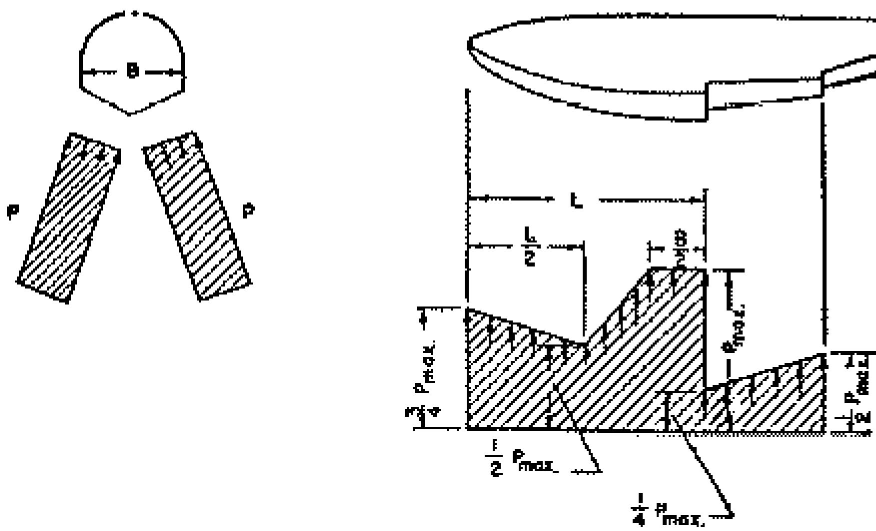


FIG. 3-13 DISTRIBUTION OF LOCAL PRESSURES (BOAT SEAPLANES)

(c) Application of local pressure. The local pressures determined in paragraphs (a) and (b) of this section shall be applied over a local area in such a manner as to cause the maximum local loads in the hull bottom structure.

§ 3.268 Distributed bottom pressures.

(a) For the purpose of designing frames, keels, and chine structure, the limit pressures obtained from § 3.267 and Figure 3-13 shall be reduced to one half the local values and simultaneously applied over the entire hull bottom. The loads so obtained shall be carried into the side-wall structure of the hull proper, but need not be transmitted in a fore-and-aft direction as shear and bending loads.

(b) Unsymmetrical loading. Each floor member or frame shall be designed for a load on one side of the hull center line equal to the most critical symmetrical loading, combined with a load on the other side of the hull center line equal to one-half of the most critical symmetrical loading.

§ 3.269 Step loading condition—

(a) Application of load. The resultant water load shall be applied vertically in the plane of symmetry so as to pass through the center of gravity of the airplane.

(b) Acceleration. The limit acceleration shall be 4.33.

(c) Hull shear and bending loads. The hull shear and bending loads shall be computed from the inertia loads produced by the vertical water load. To avoid excessive local shear loads and bending moments near the point of water load application, the water load may be distributed over the hull bottom, using pressures not less than those specified in § 3.268.

§ 3.270 Bow loading condition—

(a) Application of load. The resultant water load shall be applied in the plane of symmetry at a point one-tenth of the distance from the bow to the step and shall be directed upward and rearward at an angle of 30 degrees from the vertical.

(b) Magnitude of load. The magnitude of the limit resultant water load shall be determined from the following equation:

$$P_b = \frac{n_s W_e}{2}$$

where:
Pb = the load in pounds
Ns = the step landing load factor.
We = an effective weight which is assumed equal to one-half the design weight of the airplane.

(c) Hull shear and bending loads. The hull shear and bending loads shall be determined by proper consideration of the inertia loads which resist the linear and angular accelerations involved. To avoid excessive local shear loads, the water reaction may be distributed over the hull bottom, using pressures not less than those
specified in § 3.268.

§ 3.271 Stern loading condition—

(a) Application of load. The resultant water load shall be applied vertically in the plane of symmetry and shall be distributed over the hull bottom from the second step forward with an intensity equal to the pressures specified in §§ 3.267-3.272.

(b) Magnitude of load. The limit resultant load shall equal three-fourths of the maximum design weight of the airplane.

(c) Hull shear and bending loads. The hull shear and bending loads shall be determined by assuming the hull structure to be supported at the wing attachment fittings and neglecting internal inertia loads. This condition need not be applied to the fittings or to the portion of the hull ahead of the rear attachment fittings.

§ 3.272 Side loading condition—

(a) Application of load. The resultant water load shall be applied in a vertical plane through the center of gravity. The vertical component shall be assumed to act in the plane of symmetry and horizontal component at a point halfway between the bottom of the keel and the load water line at design weight (at rest).

(b) Magnitude of load. The limit vertical component of acceleration shall be 3.25 and the side component shall be equal to 15 percent of the vertical component.

(c) Hull shear and bending loads. The hull shear and bending loads shall be determined by proper consideration of the inertia loads or by introducing couples at the wing attachment points. To avoid excessive local shear loads, the water reaction may be distributed over the hull bottom, using pressures not less than those specified by § 3.268.